

A photograph of a fishing boat deck. Two men are visible; one is bent over a large pile of small fish, and the other stands nearby. The sea is in the background. The image has a slightly aged, grainy quality.

Fish By-Catch . . . Bonus From The Sea

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Bonus From The Sea

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Report of a Technical Consultation
on Shrimp By-Catch Utilization held in
Georgetown, Guyana, 27-30 October 1981



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Contents

Preface 5

Introduction W.H.L. Allsopp 7

Summary 9

Conclusions and Recommendations 17

Background

Utilization of the Shrimp By-Catch **Joseph W. Slavin** 21

Use of Fish By-Catch from Shrimp Trawling: Future
Development **W.H.L. Allsopp** 29

By-Catch for Human Consumption **E.R. Pariser** 37

Assessment of the Resources

By-Catch from Shrimp Trawling in Guyanese Waters **Donald J.
Furnell** 43

Fish Discards from the Southeastern United States Shrimp
Fishery **Gilmore Pellegrin Jr** 51

Yields and Composition of By-Catch from the Gulf of California
**J. Perez Mellado, J.M. Romero, R.H. Young, and L.T.
Findley** 55

Processing at Sea

Handling Mixed Catches **Karsten Baek Olsen and Poul
Hansen** 59

Strategies to Avoid By-Catch in Shrimp Trawling **V. Sternin and
W.H.L. Allsopp** 61

Handling and Storage of Shrimp By-Catch at Sea **K. Crean** 65

Processing on Shore

The Guyana Project: Industrial Use of By-Catch **E. Ettrup
Petersen** 69

Effects of Acetic-Acid Aided Evisceration on Deboned Minces from By-
Catch Fish **Nigel H. Poulter and Jorge E. Treviño** 77

Salting of Minced Fish **E.G. Bligh and Roseline Duclos** 81

Concentration and Preservation of Mechanically Recovered Fish
Flesh **Poul Hansen** 84

Processing of By-Catch into Frozen Minced Blocks (Surimi) and Jelly
Products **Tan Sen Min, Tatsuru Fujiwara, Ng Mui Chng, and
Tan Ching Ean** 89

4 BY-CATCH

- Development of a Salted, Minced Product from Mexican Shrimp By-Catch **R.H. Young** 93
- Canned, Frozen, and Dried Products from By-Catch Fish **Nigel H. Poulter** 96
- Acceptability and Storage Characteristics of Frozen, Minced Products from Mexican By-Catch **M.A. Tableros and R.H. Young** 99
- Pepepez — a New, Frozen Minced Product **Productos Pesqueros Mexicanos** 101
- Fish Silage from By-Catch **J.E. Treviño, R.H. Young, A. Uvalle, K. Crean, D.H. Machin, and E.H. Leal** 103

Marketing, Economic, and Resource-Management Aspects

- Possibilities of Marketing Shrimp By-Catch in Central America **Miguel S. Peña** 107
- Financial Projections for Industrial Production of Minced By-Catch Fish **R.H. Young** 110
- Optimization of Processing of Three Underutilized Fish Species **John W. Brown and Melvin E. Waters** 113
- Economic Profiles for Three Products Made from By-Catch **I. Misuishi** 118
- Management of Shrimp Fisheries **J.F. Caddy** 120

Regional and Country Developments

- Fishery Development: the Latin American Model Revisited **Julio Luna** 125
- French Guiana **M. Lemoine** 128
- Guatemala **Etienne Matton** 130
- Guyana **Ronald M. Gordon** 131
- Sabah, Malaysia **Datuk Chin Phui Kong** 135
- Mexico **José Manuel Grande Vidal and María Luz Díaz López** 137
- Mozambique **H. Pelgröm and M. Sulemane** 139
- Sri Lanka **S. Subasinghe** 141
- Thailand **Bung-orn Saisithi** 143

Bibliography 147

Participants 161

Use of Fish By-Catch from Shrimp Trawling: Future Development

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Much investigation and industrial development in fish by-catch use has taken place since my review (1980) presented to the Inter-American Development Bank (IDB) Round Table on Non-Traditional Fishery Products. However, there are critical areas for further study to resolve technical and economic constraints in each system. In this paper, I have indicated these as well as some locations where relevant developments are being investigated. Specific subjects for international action are identified in the fields of gear, vessel modification, product development, and resource management.

At present, the by-catch of shrimp trawling is usually discarded — a waste that has serious implications for food consumption in tropical countries where many fisheries are already shrinking in production. Further, because the total marine catch is some 6.3×10^7 t, of which 4.3×10^7 t is consumed, the use of the by-catches could enlarge fish supplies to protein-deficient areas in a major way.

Fish Available

Because of the variations in the seasons, ocean floor, water currents, time of day of fishing, migratory patterns of groundfish, etc., it is impossible to arrive at a fixed ratio of fish to shrimp even in a particular area of a fishery. Catches vary considerably, especially where seasonal currents or estuarine outflows cause temperature changes or where the

associated fauna are diverse. Thus, fish by-catch in Mexico's north Pacific coast (Baja California) is much different from off Tehuantepec, and it is completely different from the Yucatan, Colombian, or Guyana species combinations on the Atlantic coasts. Although it is an oversimplification to give a ratio of 5 : 1 by-catch/shrimp in fisheries in temperate waters and a 10 : 1 ratio for tropical waters, it is a useful guide.

The size of fish caught is also variable. A broad classification according to market demand is:

- Large marketable species;
- Marketable species of medium sizes (15–25 cm) and larger unusual species; and
- Small fish of marketable characteristics (white flesh, few bones, etc.) or unusual species less than 14 cm.

This classification can be subdivided into quantities by species groups. If one accepts these categories and recognizes that, in each country, fish that are marketable vary considerably, it will be appreciated that what is available for human consumption varies even further and that total by-catch estimates of discards or marketable species for any given fishery are rather subjective.

The FAO figures for by-catch discards have changed over the years from 3×10^6 t to 6×10^6 t. A National Academy of Sciences (NAS 1978) study encompassed a range of what may be edible and what may be used only for industrial purposes. The U.S. Gulf of Mexico fisheries have recently indicated a figure of about 1×10^6 t for their vessel discards.

Clearly, there is an enormous cumulative waste through discards, and, although much time may be spent on arguing its accurate estimation, efforts to quantify the by-catch in different areas would be more profitable. Preliminary work has been started in the Guyana/IDRC project. The U.S. National Marine Fisheries Service (NMFS) has analyzed data based on statistical samples and has extrapolated the results to the vessels operating in the Guyanese fishery. Donald Furnell, in a report to IDRC, indicated that an average 2×10^4 t fish were caught as by-catch during each of July and August by the Guyana fleet. This figure may be typical for the rainy season only, and data have to be collected from several boats during different seasons and in different locales. The patterns of availability and capture of fish/shrimp in different zones in other countries and for the

duration of the seasons are important baseline data. Such assessments form the basis for further industrial action.

To be meaningful, the quantities of fish should be grouped according to their flesh characteristics for industrial end-use. The result of the removal of fish stocks and the management implications of this fishery are relevant issues that must also be faced.

Recovery, Handling, and Preservation

Whenever there is a large quantity of fish caught during shrimp trawling, the crew must devote considerable time and effort to sorting and separation. This fact has led to the design of separators, excluders, and escapement chutes in trawls. The objective has been to land a clean catch of shrimp. Most of these designs have been developed for fisheries of northern and temperate waters where the quantities of fish and the behaviour of the shrimp are somewhat different from those in tropical waters. The bibliography in this publication lists many of these. My understanding, from personal communication with the authors is that, with further studies and modifications, the principle of presorting can be perfected and applied to tropical penaeid fisheries. Such a development would facilitate the sorting of shrimp and fish, reduce handling time, and permit better preservation. It would require skilled net rigging and use. Further applied research on other gear improvements is important if catch efficiency and handling are to be improved. The different systems for separation, as well as the wide-opening, catchall trawls developed by Deep-Sea Boatbuilders of Bayou la Batre, Alabama, should be assessed and standardized. The proposal for a study to test the use of sound to direct the fish away from the trawl is also promising for joint-venture enterprises fishing in the exclusive economic zones (EEZs) of tropical countries.

Part of the reason that the by-catch is discarded is the limited space aboard the shrimp trawler. One way to alleviate the space limitation is to sort the fish mechanically as the cod end of the trawl is discharged. Other technical options involve stowage systems that include facilities for freezing, CSW storage, or mechanical systems of handling in bulk. The cost-efficiency of these options,

however, has yet to be evaluated. There have already been new designs introduced for boats in Mexico and in the USA (Bayou la Batre, Alabama) with greater space for storage and crew members. The results of their operations in the fisheries should be carefully assessed. However, because of climatic conditions, fish abundance, and cultural customs, the designs may not be totally transferable to more tropical areas.

Specific additional needs include:

- Improvements in harvesting gear on the vessels;
- A simple mechanical device for separating, grading, and sorting the fish by sizes aboard the vessels (after being graded the fish can be sorted into species groups more easily and stored as such; in this regard, the Danish experience is relevant);
- Study of the stowage space required for shrimp and fish (according to the operational locality of the vessel) as a basis for redesign of vessels for specific fisheries; and
- Techniques and equipment for efficient handling aboard and for port discharge.

The use of small trawlers that make short trips (no longer than 5 days) combined with arrangements for using trawlers for fish only is being attempted in some countries. The alternative — use of much larger trawlers to bring in all the catch — is operational in Alabama and Mexico and is planned for Guyana. Management studies of boat-size limitations and operational zones for particular vessels and gear may be needed as well as specific evaluations for the implementation of efficient operations.

Vessel owners have tended to replace old vessels with larger trawlers with freezing facilities, but their target has continued to be shrimp. Government enterprises (Mexico, Guyana) have begun building larger boats with CSW systems for fish and shrimp. To date, I have no knowledge of collecting systems that are in regular commercial use.

Purse seiners equipped with CSW systems are available in Mexico and may be available in off-seasons for tests of the transfer and collection at sea of fish by-catch from shrimp trawlers. The system suggested for the Guyana fleet was the use of tanks (fish-holding capacity 2 t) on deck for nightly transfer to collection vessels. In both cases, the operational patterns of collector vessels, rendezvous with trawlers, transfer of catch at

sea, the quantities of fish in particular seasons, and other variants need to be carefully analyzed.

Incorporating, in the design of larger vessels, the use of mechanical graders for the selection of species and categories, as well as possible processing (deboning) at sea, seems to be a suitable approach. If adopted, this approach would mean that transfers of catch would involve only the large species that can be sold whole at premium prices. Selected smaller species could be minced and frozen or salted for storage. Transfers would be minimized, and the bulk of fish would be reduced in the form of frozen mince, stored similarly to shrimp.

A fleet of CSW-equipped vessels is only part of the production system; another element is shore installations and plant processing to handle the catch efficiently. In a hot climate, cost-efficiency of the system is critical because refrigeration is involved. In this regard, the system of minced, salted fish developed in Canada (Halifax), if done and discharged in ports, is promising. Further, the market value of the fish and the end-use may dictate that the recovered by-catch be limited to the space available on the vessel and that, as a last resort, fish be landed for conversion as livestock feeds. The champagne-bubbling system of chilled seawater for handling, storage, and port discharge used in the Pacific northwest and in Denmark is worthy of trial on an industrial scale. The results of testing this system in Guyana and in Bangladesh should be followed closely. In an integrated system from capture to processed product, the essential stages requiring improvement have to be considered concurrently. The volume collected, the scale of pilot operations, the quantity of inputs for commercial-scale operations are all related to the products for target markets and for which a set of criteria of characteristics must be predetermined (Fig. 1).

Processing the By-Catch Ashore

There are between 70 and 200 species involved in the tropical by-catch. They vary greatly in shape and size and, even after being sorted and graded, are unsuited to the mechanical processing methods currently available. Large fish can be manually headed, gutted, etc., but small fish (which constitute

as much as 50% of the catch) require machine heading, gutting, or filleting for desirable quality and low costs. Most processing equipment (manufactured in Europe, North America, or Japan) requires modification to cope with the types of fish that are most abundant in the by-catch.

The different species of fish in the "white-flesh" category may have to be subdivided according to flesh colour, texture, elasticity or toughness after cooking, and their suitability when mixed with cereals or starchy food additives. There is considerable variation among species and among the same species during different seasons. Accordingly, tests related to the end-use of different species should be done. Specifically, the texture, toughness, etc. of minced fish after being frozen or cooked have been found to be quite variable. Mixes of different fish flesh may thus result in textures of end-products that are not uniform. Further, mixes that include fatty fish may undergo rapid denaturant reactions even when frozen.

Tests for product development, therefore, must involve careful study, preferably in well-equipped, food-processing laboratories, of the flesh characteristics of the prime species available. The results can contribute to product formulation suited to various national and cultural tastes.

Logical steps in promoting the development of food processing move from pilot-plant operation through commercial production to consumer product development, testing, and evaluation. Storage, shelf-life, packaging, standards, grades, and promotional methods are involved. On a local or national scale, these are formidable tasks. The international or regional scale should only be considered when domestic markets are satisfied and the profitability of operations is established. The requirements of international markets involve considerable financial inputs for promotion of new products and assured volume. Joint-venture enterprises may facilitate such activities after the local operations have had experience in effectively handling the available by-catch resource.

The large, marketable species can be sold in traditional forms, which include fresh or frozen fillets, steaks or dressed fish, and preserved products. Increasingly, however, it has become evident that whole, dressed fish or frozen fish are less commercially profitable in tropical countries than are various stable products. The reasons are the low purchasing

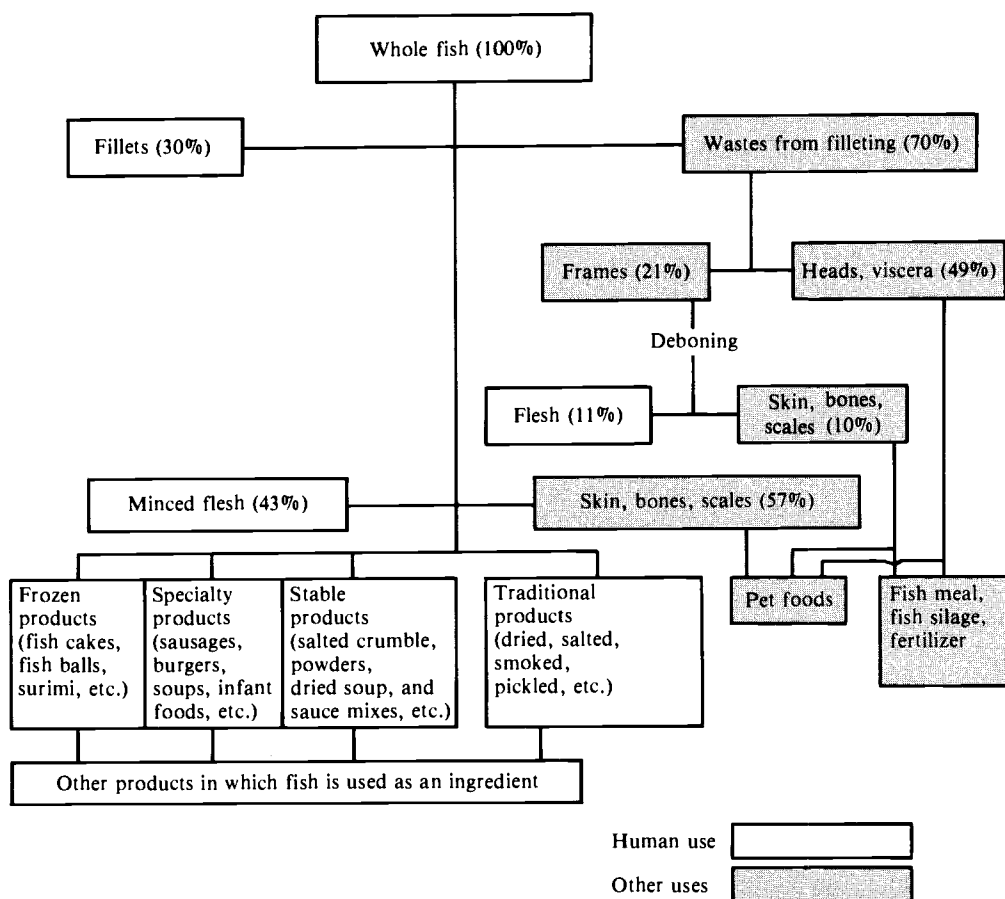


Fig. 1. Approximate recoveries in processing of by-catch fish.

power of the populations, the importance of fish as a source of protein, demand for fish, and the increasing costs of refrigeration, electricity, and fuels. Although frozen storage may be accessible to high-income urban dwellers in the tropics, it is too costly for others, especially rural consumers. Thus, products that require minimum energy inputs and are stable at ambient temperatures are desirable. These include salted, sun-dried, and pickled products. The methods for making pickled and smoked or barbecued products are already in use but need improvement and standardization. To provide products that are acceptable, bulk-produced, effectively packaged, with adequate shelf-life, requires further developments and studies with selected species. This is the area of greatest challenge for researchers: to develop bulk processing of dried, salted, or pickled fish on a scale of at

least 10 t/day as well as on a village scale of 2 t/day. Standard quality and effective packaging require special attention.

Nontraditional products offer a wide range of possibilities and have been the subject of many developments using deboning machines. In Mexico, Colombia, the U.S. (Alabama), Guyana, Nigeria, India, and Malaysia (Sabah), various products are being made by this method. For instance, minced croaker seems acceptable for the Japanese surimi market. Various flesh-and-bone separators are available, but few are really ideal to cope with the variety within the by-catch. What is needed is a machine that can:

- Process a wide range of sizes of fish;
- Recover a maximum amount of flesh without bones;
- Be cleaned easily, with few wearing parts in need of replacement;

- Be constructed from long-lasting materials; and
- Handle large throughput for economical plant operation.

Some consider that a small plant (2 t/day) may be effectively used on a trawler; others urge a large deboner (20 t/day) for onshore installations. In any event, there is a need for modification of current machinery to deal efficiently with the fish available in the by-catch.

Once minced, the fish flesh is versatile (Fig. 1). Not only is mincing an efficient way to recover flesh for direct use as human food, but also a wide range of by-products, such as pet foods and livestock meal, can be made from the bones as well as the scales, liver, swim bladders, etc. Such products have already been developed in advanced technical laboratories and commercial plants using fish from trawl fisheries of temperate waters. Studies on flesh characteristics to test the suitability of the different fish types for various products in local markets are necessary. In addition, shrimp heads offer opportunities for valuable products.

The aim should be to produce new types of "convenience products" that are stable at room temperatures; have a shelf-life of 1 year; are packaged against insect attack, moisture loss, and denaturing; are suitable for quick domestic or institutional use; and require a limited amount of preparation before being brought to the table.

Snack products, such as fish crackers, biscuits, etc., developed according to local tastes with spices, peppers, etc., are already made from minced fish. Their inclusion in Mexican tacos, tortillas, Indian rhotis, and Indonesian krupuk or fish fritters has already been done. In addition, burgers, pastes, sausages, wafers, rolls, and puffs, in which fish are used as an ingredient, are available. Such products will cater to middle-income earners, institutions, and urban communities. There is clearly a market for them, and it is increasing in most tropical countries.

Oily species that are part of the by-catch have been considered suitable for use in fish meal and cooking oil. Some of the smaller species of mackerel are pickled, the larger ones being directly consumed. A smoked fish pâté, using cavalle, is a new product that found ready market acceptance in Guyana.

Livestock feeds logically form part of the recovery systems for by-catch fish. The small-

est fish caught in the trawl, rather than being discarded, can be used for fish meal if they can be economically brought to the shore plant. Simple systems of fish-meal processing at small fish-silage plants have been advocated within the past 20 years. Frames from filleting as well as processing wastes from flesh-and-bone separators can also be used in fish meal and fertilizers.

Therefore, the economical processing of by-catch seems to depend on the combination of approaches to the use of the fish available to meet consumer tastes in the local or regional markets. It would include:

- Use of large species for direct consumption in various forms;
- Manufacture of traditional products;
- Manufacture of minced fish and specialty products;
- Manufacture of pet foods;
- Recovery of wastes as livestock feeds; and
- Use of shrimp heads in chitosan and other products.

Because local-market price levels are already fixed for most of the classes of products, the opportunity for greatest development and cost recovery lies with the development of nontraditional minced products. This development would upgrade the value of the flesh of the most abundantly available, low-priced species and could present fish protein to the consumer in a highly acceptable form.

The assessment of the combination of end-products, the most profitable species of fish for minced flesh use, the quantities of product types for markets, etc. is critically important if one is to determine the most feasible commercial operation in particular situations. Such considerations are clearly affected by local circumstances of market demand, as well as international factors like fuel prices and costs of vessels and gear, even though the overriding principles of import substitution and protein self-sufficiency apply in some cases.

Processing questions may, therefore, be summarized as:

- How do the flesh characteristics of principal species of the fishery affect minced products, and how is the texture affected by different combinations of processing steps (such as mincing, freezing, and then converting into mixed products compared with freezing, thawing, mincing, and converting)?
- What are the best uses for the abundant

species in the by-catch as a reflection of studies on the products best suited for distribution, the products most profitable in processing, the target market (institutions, rural residents, urban dwellers); the economic mix of products needed to make a commercially viable operation; the price that the market can bear; the maximum price to the producers?

- What other technical and economic decisions need to be taken for use of different species for various products?
- How do taste panels react to the products developed?
- What are the characteristics of the products, i.e., what is their shelf-life; can they be produced in bulk for institutional use?
- And what are the characteristics of the postproduction system, i.e., does it include items that have fish as an added ingredient (soups, bread, tortillas, biscuits); low-cost, fortified traditional foods; specialty products (high value) including chitosan from shrimp heads; and animal feed?

After products have been made successfully on a pilot scale, testing of large-scale production should begin and should include cost analyses. In areas where market demand for fish outweighs supplies, test-marketing of by-catch products can be undertaken mainly on the basis of taste-panel testing. In some cases, governments or donor agencies may subsidize efforts to popularize products and get them to the target populations. An interesting regional market survey has been made for six Caribbean territories with the products from Guyana. Yet, to date, the costs and benefits of using different species in products have not been evaluated systematically in relation to the target market — what the consumers want or require most and what price they can afford.

Market studies need to reach both rural and urban consumers as well as those who buy food for institutional programs. The variations in products for specific locales (storage, shelf-life, transport, etc.) are important factors to be considered in local as well as regional surveys. Another important factor is quality. Although domestic markets may permit products of variable standards, international or regional markets require adherence to fixed international standards of the Codex Alimentarius.

The major outlet for minced fish products

prepared as convenience foods is institutional food kitchens, i.e., schools, hospitals, etc. School-lunch programs, office canteens and cafeterias, quick-food outlets, food services in health-care centres or confinement institutions are excellent opportunities for the bulk sale of well-compounded fish preparations. Standard quality, hygienic excellence, and attractive taste are essential in such markets; a dependence on the nutritional value of products is clearly not enough.

One method to reach the institutional market is to prepare minced flesh in bulk, provide it to food-processing outlets, and then move the products to the target institutions. Bulk preparation could include dried, salted fish "crumble," dried soup mixes, fish sauces, etc. at standard mixes distributed for institutional use or packaged for sale to individuals.

In tropical countries, the outlets that would be processing fish for human consumption should be separated from the fish-landing areas where preliminary handling and processing take place. In contrast, the manufacture of livestock feed from industrial fish, fish offal, trimmings, and the wastes from the deboning machine should be close to preliminary-processing operations.

Economic Aspects

The critical reasons that by-catch fish have been discarded are market value in relation to shrimp and stowage space aboard a trawler. If the value of the fish were increased through processing activities, the shrimpers might be convinced of the benefits of collecting the by-catch, especially if the cost-benefit compared well with that for shrimping. A cost-benefit comparison needs to be based on:

- An operational cost analysis for shrimp fishing with different boat types (equipped with freezers, ice, CSW), including fuel, maintenance, machinery depreciation, and catch returns in specific fisheries;
- An economic study of the opportunity costs in the use of stowage hold for shrimp and fish during trips in different operational areas (most shrimp trawlers return with half-empty holds that could have been carrying fish without damage to the quality of stored shrimp, according to evidence from Mexican operations that offer a variety of conditions for study in

standardizing the system of stowing by-catch and shrimp);

- A study of the patterns of capture (volume of fish/shrimp) and an assessment of the value of residual space at the end of shrimping trips; this information could be used as a basis for timetables for stowage use of the hold; and
- A realistic cost structure for different categories of by-catch that would serve as an incentive to owners and crews to collect fish of good quality for food processing (not livestock meal).

Products that increased the market value of by-catch not only would result in enlarged sea operations but also would have a multiplier effect on employment, generated by shore-based activity for food products, livestock feeds, etc. Another social factor, although difficult to evaluate in economic terms, is especially important: food self-sufficiency and the use of nationally available resources. Further, processing the by-catch for human food would provide an insulation against spiraling prices of imported foods.

Regulatory, Legal, and Monitoring Aspects

At present, data on catches are scanty; there have been few surveys of the by-catch fish during commercial shrimp trawling. However, some surveys have indicated the catch of shrimp or of fish; for instance, U.S. survey data for fishing in the north of the Gulf of Mexico and off the Guyana banks are being analyzed. In other areas, specific data may be extracted from shrimp-fishing records in logs of operations — for example, from Japanese-owned trawlers — and from operational catch data reported daily — for example, for trawlers fishing along the Atlantic coast of Colombia for Vikings. Other data are available for Sabah, Malaysia, and Andhra Pradesh, India, as well as for areas off Bangladesh.

Constraints on data collection include the limited space available even for crews on trawlers, the limited numbers of personnel skilled in navigational reporting, and the limited interest in fish (quantity by species). Because of the variations of catch in different locales and seasons, the data available are generally not suitable as a basis for industrial applications and are even less suitable for regulatory or management measures for fish

or shrimp. The navigational fix of the trawling area, the water currents, sea floor, temperature, etc. have been recorded only in surveys done by research vessels. Furnell in a report to IDRC suggests a simple sampling system for catch data. The actual catch of shrimp is generally well recorded, but the location of capture is generally vague and even secret.

By-catch data must be recorded by vessels and must be accumulated for assessments about management and monitoring. Data assessment systems should be standardized, captains trained, and logs or records required. In some countries, e.g., Colombia, each vessel must report daily its location (for security control), and this information can facilitate shore-based monitoring of catches. In certain fishing operations, national data collectors are reported to be aboard foreign vessels to record catches from their countries' exclusive national fishing zones.

The EEZs were set up as a means to introduce better management of the resources within the waters along the coastal areas of the world. One possible management strategy is to restrict fishing in waters up to 15–20 fathoms to national artisanal fishing enterprises; to allow offshore (perhaps within 20–45 fathoms) trawling for shrimp and fish seasonally or by limited numbers of vessels; and to consider the remainder (40–100 fathoms) of the area within the EEZ the domain of foreign vessels with specialized gear such as separator trawls, etc. (Fig. 2).

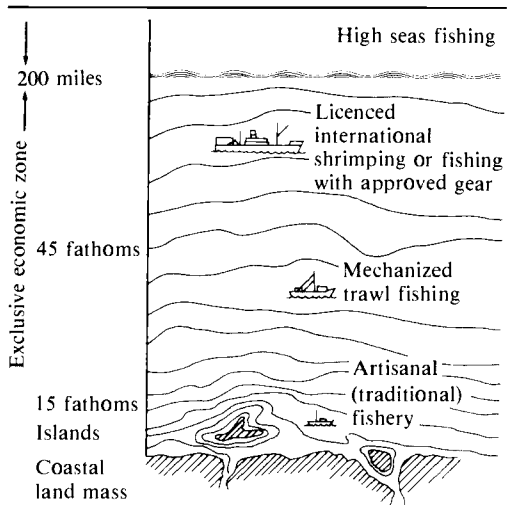


Fig. 2. Possible zones for shrimp fishing.

A complete management strategy, however, must include regulations on mesh size and other gear. The FAO regional fisheries commissions must take the lead in providing the technical basis for regulatory measures and their cooperative application by all countries fishing the resources. Some centres already have experience in such data analysis, and they should be identified and their collaboration enlisted. In this regard, the industrialized fishing nations, particularly Europe, North America, and Asia, can provide useful leadership and training opportunities in specific aspects of resource studies, management measures, and product-development standards. The centres that are involved in data analysis from overseas shrimp fisheries have a special opportunity and responsibility for the national use of by-catch fish.

Quality control of exported products made from the by-catch is governed by international regulations. Standards for national products are equally important, for they ensure that high-quality food products are available for human consumption and they present an opportunity to eliminate the slur and uneasy image of by-catch in the past — trash fish to be thrown away or used only in animal feed. Therefore, enforcing hygienic and quality standards is essential, particularly because the fish species now have low consumer demand. Lapses in quality of marketed products will seriously damage consumer-promotion strategies.

Special Regional Developments

The geographic area where activity for by-catch use is primarily evident is the Gulf of Mexico and Latin America. However, in West Africa, the Indian Ocean, South China Sea, and the Indonesian seas, various activities have been initiated. Although there are many traditional fish sauces and minced products in use in the Indo-Pacific area, particular emphasis has recently been given to fish silage and community processing because of massive quantities of small fish in the by-catch from the Gulf of Thailand, Bay of Bengal, etc.

Challenging opportunities for technological research and development in capture and processing include:

- Improved design of trawlers to catch and separate (or exclude) the fish from the shrimp;

- Redesigned vessels to accommodate the total catch safely and economically;
- Mechanical fish sorters and graders for on-board operation;
- Efficient storage, collection, and transfer systems in vessels;
- Processing techniques that accommodate different flesh characteristics and product development;
- Modifications of filleting and processing machinery so that it can cope with the bulk of the by-catch species harvested; and
- Management systems for sustaining resource yields.

Already, in governmental or industrial laboratories, skilled personnel address these challenges. However, they are finding solutions and designing systems to fulfill the requisite need for their specific fishery. What seems to be needed is the acceptance of the prime importance of these challenges in contributing toward food benefits and toward an integrated multiplier effect. Clearly, if enough effort were devoted to the meeting of these challenges, results would be attained within a few years. A concerted effort at training and the effective application of the principles, with systems tailored to the different geographic and national locations, is needed so that the recovery of the by-catch fish increases dramatically.

Investment banks should consider devoting funds toward solving some of the specific problems in by-catch use as well as toward developing the needed production methods and infrastructure. I believe that concerted international efforts can reap the rewards of by-catch use and that the rational management of such resources under the new regime of the oceans will make the greatest possible contribution to the resolution of the planetary food shortage.

This paper summarizes my observations of fishery operations in the production and processing of fish by-catch in several countries during 1980–81. The observations and discussions with personnel in the USA, Denmark, England, Mexico, Colombia, and Guyana reflect activities and constraints at the production and processing centres. I very much appreciate the frank discussions with such technical personnel and the opportunity to observe many processing operations, gear modifications, and new vessels. Also I have drawn on correspondence and literature sent to me by fishery personnel.